Space Weather Technical Forecast

Issued on Saturday, 24 June 2023 at 01:13 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of R1/R2 Radio Blackouts throughout. Slight Chance of G1 Geomagnetic Storm to start and especially to end the four days.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate in the last 24 hours, with GOES16 recording the falling limb of a peak M4.8 flare immediately prior to the start of this reporting period (emitted from AR3341 at 22/2344UTC).

There are currently eleven sunspot regions on the visible disc. The most active, AR3341, still appears relative simple magnetically in its stable Csi/Beta configuration, but it remains the case that it occupies a large plage area that may harbour some complexity. The largest group remains AR3340 in the north centre-disc, with a Dsi/Beta classification and a spreading tendency visible. There was also some reconfiguration within AR3345, AR3340 and AR3335, with no significant areal change and little accompanying flare activity. The remaining spots showed little change.

The filament mentioned immediately to the east of AR3341 in recent guidance lifted off with the sunspot region's M4.8 flare of 22/2344UTC. In part because of SOHO manoeuvres rendering C2 difference imagery less useful, and also because the bulk of the ejecta heading southeast of the Sun-Earth is hidden by the mirror mount for Lasco C3, analysis has proven difficult. Having said this, a reasonable match for modelling was obtained to the estimated Type II speed of 534km/s. A Type IV radio burst was also observed with the flare.

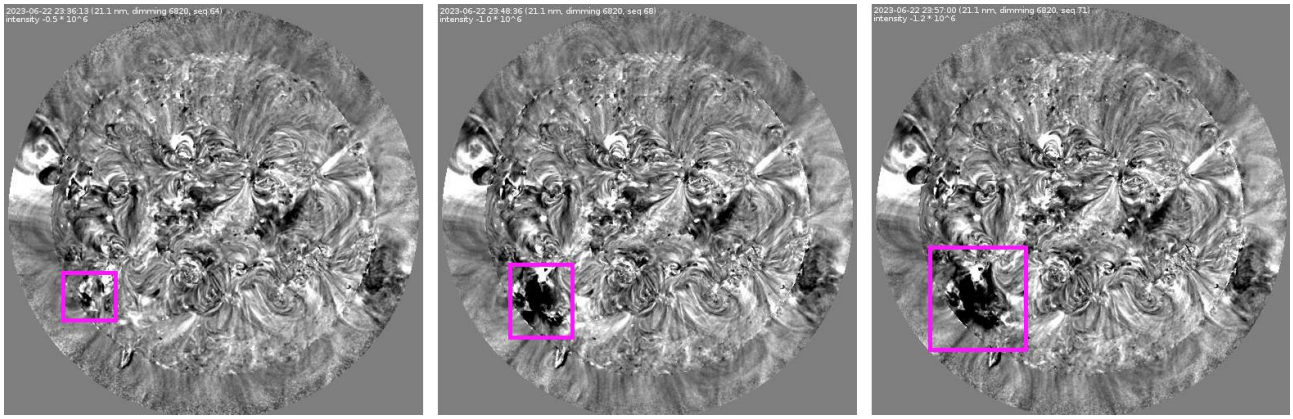

Figure 0: SIDC ROB-processed AIA211 time-integrated dimming of the M4.8 flare and filament eruption from AR3341 at 22/2344UTC. This has been determined to possibly deliver a glancing blow of Earth around the turn of the UTC day of 26 into 27 June.

Coronagraph imagery for the past 24 hours is dominated by the aforementioned AR3341 M4.8 and southeast-heading filament. This has been modelled using limited imagery but shows as a possible glancing blow around the turn of the UTC day late 26 June, (or more likely) into early 27 June.

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Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR and ACE at L1, showed a declining but then resurgent connection to a negative polarity coronal hole high speed stream. The precise source remains uncertain, but is either the diffuse tail of CH15/-, or the more pole-ward CH13/-. The phi angle was accordingly mainly negative (towards the Sun).

Solar wind speeds have remained mainly Slightly Elevated, tracking near 400km/s for much of the period before a late increase to nearer 450. The solar wind density has been within typical background levels in single figures ppcc, but with a slight fall observed as the speed rose. The IMF initially followed a steady trend near 6nT before increasing to 9nT, with the north-south component erratic between +/-7nT.

The net result of the above solar wind measures was for provisionally Quiet to Unsettled geomagnetic activity, peaking at Kp '3+' in the 09-12UTC interval.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as observed by GOES16, was at Background levels.

High energy electron flux (greater than 2MeV), as observed by GOES16 ranged between Normal Background and High levels, with a peak value of 1450pfu at 23/1730UTC. The associated 24-hour fluence showed a slightly declining trend through the day, reaching 3.05e7 integrated pfu at 24/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity carries a Chance of returning to Moderate, with isolated M-class flares most likely from AR3341, as in recent days.

Solar Wind / Geomagnetic Activity: Both the CME and fast wind parts of the forecast are relatively intertwined in the coming days.

A glance from the 20 June CME may combine with an expected slightly enhanced solar wind currently observed at STEREO A, around half a day upstream of Earth in the Parker Spiral. These may give a Slight Chance of G1. Activity should be more reliably Quiet later in the UTC weekend and at first in the new working week, however the 22 June M4.8 filament CME may also glance Earth late on 26 or more likely into early 27 June to give a second peak Slight Chance of G1, with this too perhaps riding on an enhancement from either CH16 or 17's CIR.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels, with a slowly increasing daily Slight Chance of S1 or greater.

High energy electron flux (greater than 2MeV) is likely to remain near currently observed levels in the period. The corresponding 24-hour integrated fluence to most likely remain under the Active threshold.

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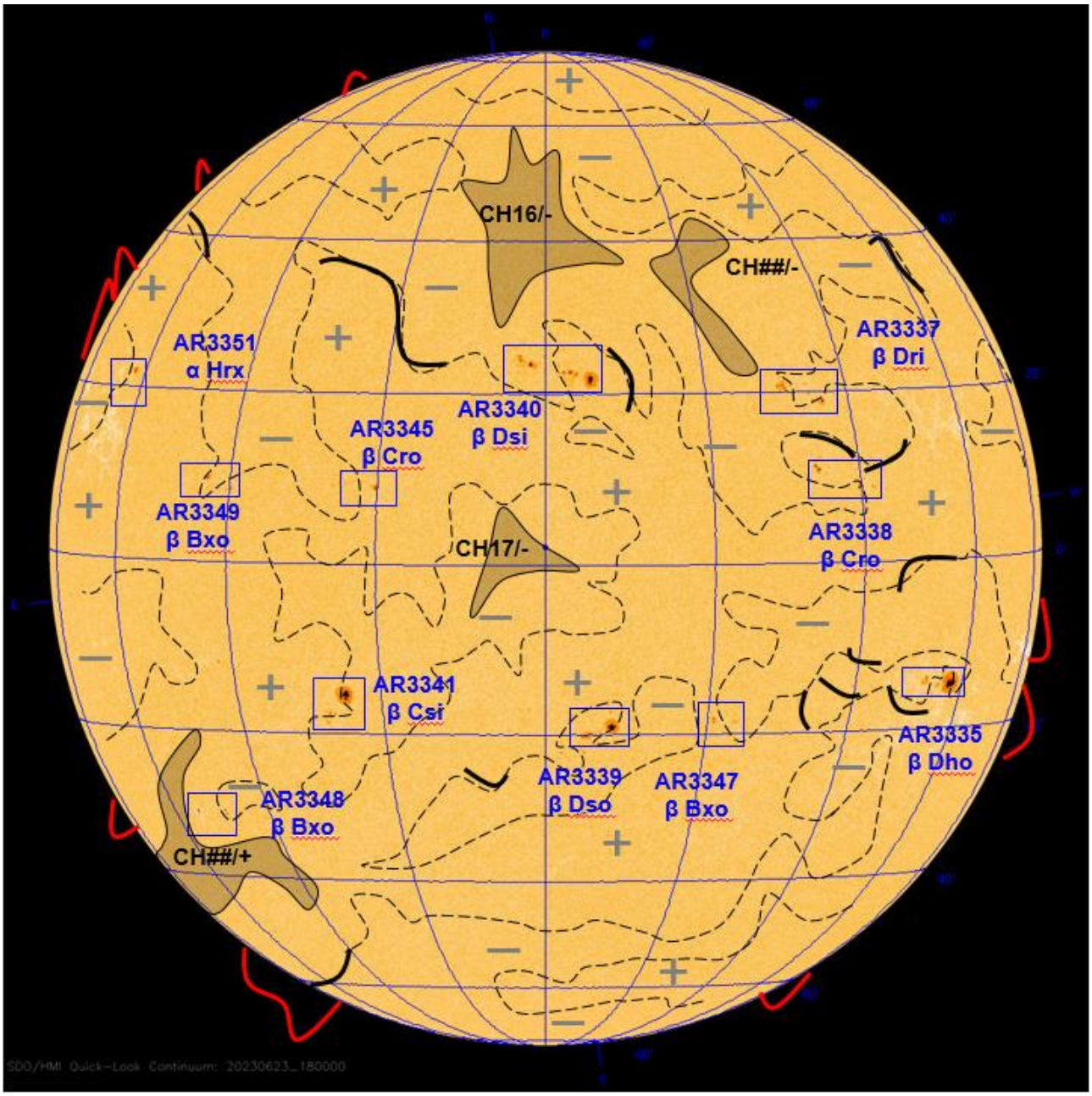
Figure 1. Solar Analysis Valid 23/1800UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

Both the CME and fast wind parts of the forecast are relatively intertwined in the coming days, and are treated as one entity below.

It is possible that CMEs emitted east of the Sun-Earth line earlier this week (20 June) may just bring a glancing blow within day one, Saturday 24 June - as shown by a minority of MOSWOC Enlil ensemble members. This not the favoured forecast, and the deterministic unperturbed run is preferred. Having said this, STEREO A MAG and PLASTIC measurements are showing an

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enhancement within a negative phi angle sector in recent hours, perhaps a transition between negative coronal holes, although this is conjectural. CH15/- ought to have passed given its position on the west limb, and CH13 was assumed to have taken over, but a late arrival of the latter may be the cause of STEREO's enhancement. Whatever the cause, The IMF may increase in the coming hours, perhaps prolonging the Slight Chance of G1 still further into the UTC weekend when considered with any 20 June CME, although the magnitude of solar wind speed should not appreciably increase from current Slightly Elevated levels.

In addition to the above, there is now a second glancing incidence CME in the forecast - that emitted from the southeast-directed filament tied to the 22/2344UTC M4.8 from AR3341. This also shows as a glancing blow, but with significantly more MOSWOC Enlil ensemble members favouring its arrival (compared to the 20 June CME). This 22 June CME is expected to pass 1AU around the turn of the UTC day late 26 June (or more likely) into early 27 June. This gives a Slight Chance of G1 partitioned between the two days, with a bias towards the latter.

This 22 June CME may arrive in conjunction with a minor CIR leading either CH16 or 17 to bolster its effects. CH17 is a small negative coronal hole currently near the solar meridian on the solar equator, while CH16/- lies at the same solar longitude and may alternatively impart some influence. Neither is expected to be particularly impactful on their own given our proximity to the solstice, and in the absence of any CME there is perhaps a Chance of Active intervals at peak.
The fact that the Type II signature was marginally faster than the speed obtained from CME fitting (534 Type II versus 493km/s fitted) implies that the CME may have slightly more of an Earth-directed component than the deterministic run suggests, hence the slight tendency to favour the minority of members with more direct incidence.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	1	10	20
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
23/0714UTC	Partial	Filament Eruption triggered by M4.8 flare AR3341	SE quadrant	476km/s	Turn of UTC day 26 into 27 June	Glance from signficant minority of MOSWOC Enlil members

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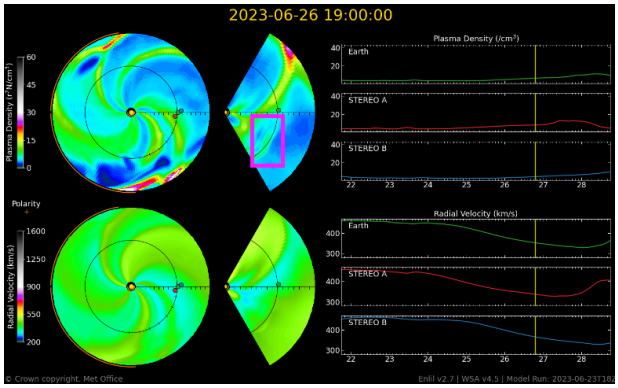
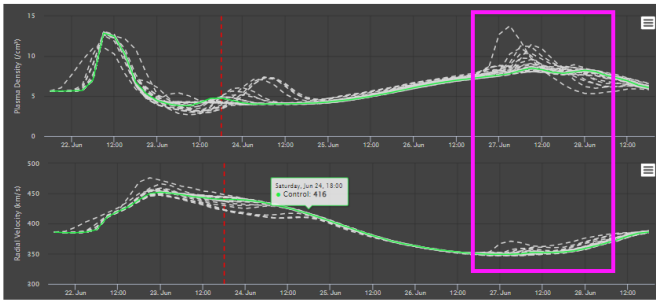
Figure 2: Latest (18Z) MOSWOC Enlil and ensemble, showing boxed magenta the 22 June M4.8 filament CME. A significant number of ensemble members show at least a glancing incidence hit, and the fact that the Type II radio burst was slightly faster than the determininstic modelled solution means that the CME is expected to be slightly nearer the Sun-Earth line than the deterministic solution.





Radio Blackouts - X-Ray Flares:

There are now eleven numbered sunspot regions on the disc, with a significant depopulation occurring relative to midweek UTC. The Penticton 10.7cm flux has fallen for the fourth day in succession to reach 170sfu, down from a high of 180 on 20 June when AR3341 produced its X1.1 flare.

Far-side soundings and STEREO A EUVI195 imagery both suggest that there is nothing imminent due over the eastern solar horizon from an Earth perspective, while only one of the leven current Earth-facing regions (AR3335) is due to depart. On balance then, because of recent trends in current spots and the expected net loss of sunspot regions, there is a daily Chance of M-class flares that should reduce into the new working week, barring any new developments.

Despite its appearance, flares are still considered most likely from AR3341, which remains on the front side throughout.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**R1-R2 M Class**	Yes	50	50	50	40
Very Active	**R3 to R5 X Class**	No	5	5	5	5

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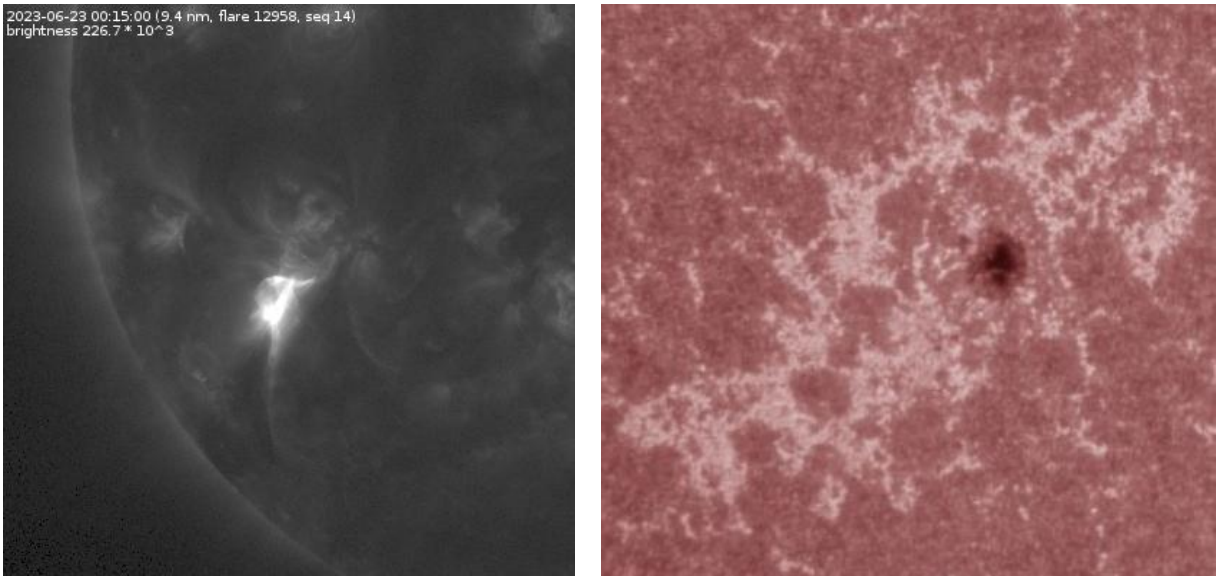
Figure 3: AR3341 in AIA094 at the time of the M4.8 flare (left) and in AIA1700, showing the large size of the containing plage relative to the simplistic contained sunspots.



Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16, is at Background levels and expected to remain so throughout the period.

There remains a daily Slight Chance of reaching the S1/Minor Storm threshold given the sheer number of (bipolar) regions and complexity of the current front-side. On balance the risk is also felt to rise slightly, as fewer large sunspots are moving away from the western limb (on the far side) than are moving towards it (on the front side), leading to a gradual increase in risk, although it remains the case that no recent even very modest proton-generating events have been observed.

Radiation Storms	**Level (cm^{-2} sr^{-1} s^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ S1**	No	10	10	15	15
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) is likely to continue to follow its recent trend of diurnal variation between Normal Background and High flux. While the geomagnetic forecast is relatively complex for the period, it is not expected to be especially impactful, particularly with regard to electrons. Any fast wind enhancement is expected to be of a similar magnitude to that seen at present, i.e. around 450km/s. Probably the most impactful part of the forecast is not expected until the end of the period - any influence from the 22 June CME on days three into four, and any subsequent effects on electron fluence will probably fall outside of this forecast

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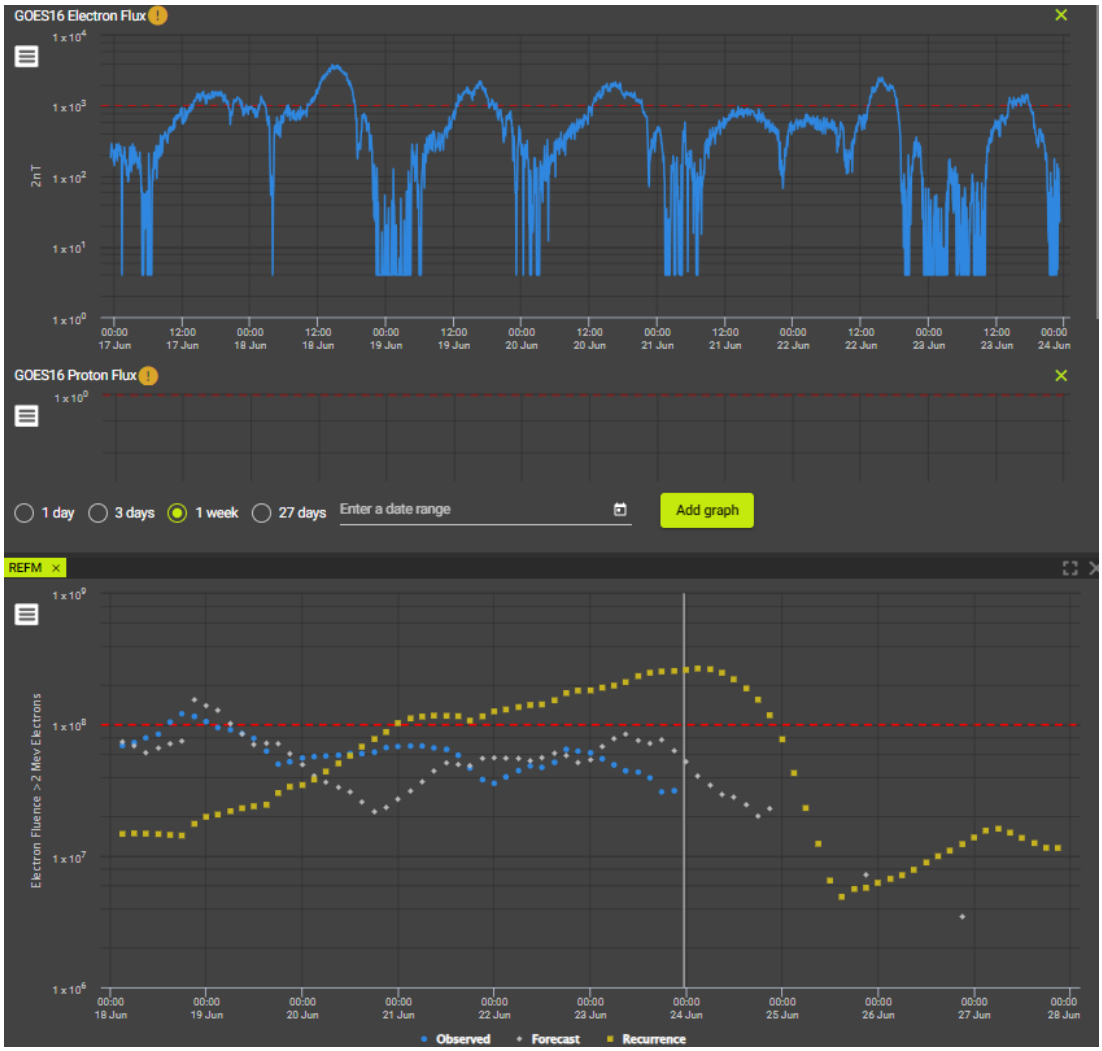
period.

MOSWOC REFM is currently offering a forecast significantly below persistence levels, which is accepted, although the influence of glancing CMEs on the geomagnetic forecast lowers confidence in values somewhat.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	20	20	10	10
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 4: Past week in high energy electron fluc (top), showing slight leaking of electrons day-on-day under the long-lasting Slightly Elevated fast wind from CH15 (and perhaps successors such as CH13). The resulting 24-hour fleunce can be seen below, as well as MOSWOC REFM predictions, which show a 72-hour continuation of sub-Active levels is favoured in the absence of any interrupting CME activity.



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